Patapsco/Back River

Final Version for 1985-2002 Data
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Patapsco/Back River Basin Characteristics

The Patapsco/Back River basin drains 630 square miles of land within Maryland's Western Shore. This area includes all of Baltimore City and portions of Anne Arundel, Baltimore, Carroll, and Howard Counties. The majority of the basin lies in the Piedmont physiographic province, but the immediate area surrounding Baltimore Harbor lies in the Coastal Plain province.

The census population in 2000 for the basin was 1,480,000 people. The City of Baltimore is the basin's largest city with suburban communities extending outward in all directions. Other major population centers in this basin include Ellicott City, Towson, and Glen Burnie.

The predominant land use in the basin is classified as urban (55 percent). Forested and wetland areas comprise the second largest land use at 24 percent. About a fifth (21 percent) of the basin is devoted to agricultural use.

Urban land use is dominant in the basin (55 percent). Nearly 96 percent of the housing in the basin is urban, with most of the remaining housing in rural areas. In conjunction with this large amount of urban housing is a heavy reliance on municipal water and sewage systems. Around 93 percent of the basin's housing relies on a municipal sewage system and 95 percent of the housing uses a public water source. Point sources are a major contributor of nutrient loadings to the Patapsco/Back River. There are six municipal sewage plants in the basin, with Biological Nutrient Removal (BNR) implemented at three of them. BNR implementation is planned for two more facilities by 2010.

About a fifth of the Patapsco/Back River basin is agricultural land. A series of Best Management Practices have been planned to help reduce non point source loads. BMP implementation for shore and soil erosion control, agricultural nutrient management plans, forest buffers, marine pumpout installation, septic connections, and stormwater management are all making good progress toward Tributary Strategy goals. Progress has been slower for other issues, such as stream protection, forest conservation and tree plantings, grassed buffers, animal waste management, runoff control, septic pumping, and urban nutrient management.

As of 2002, the most significant contributor of nitrogen in the Patapsco/Back River basin was point sources (75 percent). Following that were urban sources (19 percent) and agriculture (4 percent). For phosphorus, the largest contributor was point sources (51 percent), closely followed by urban sources (41 percent). Agricultural lands contributed 4 percent of phosphorus loadings. Urban sources were the dominant source of sediments (53 percent) followed by agriculture (32 percent).

Figure PB1 –2000 Land Use in the Patapsco/Back River Basin

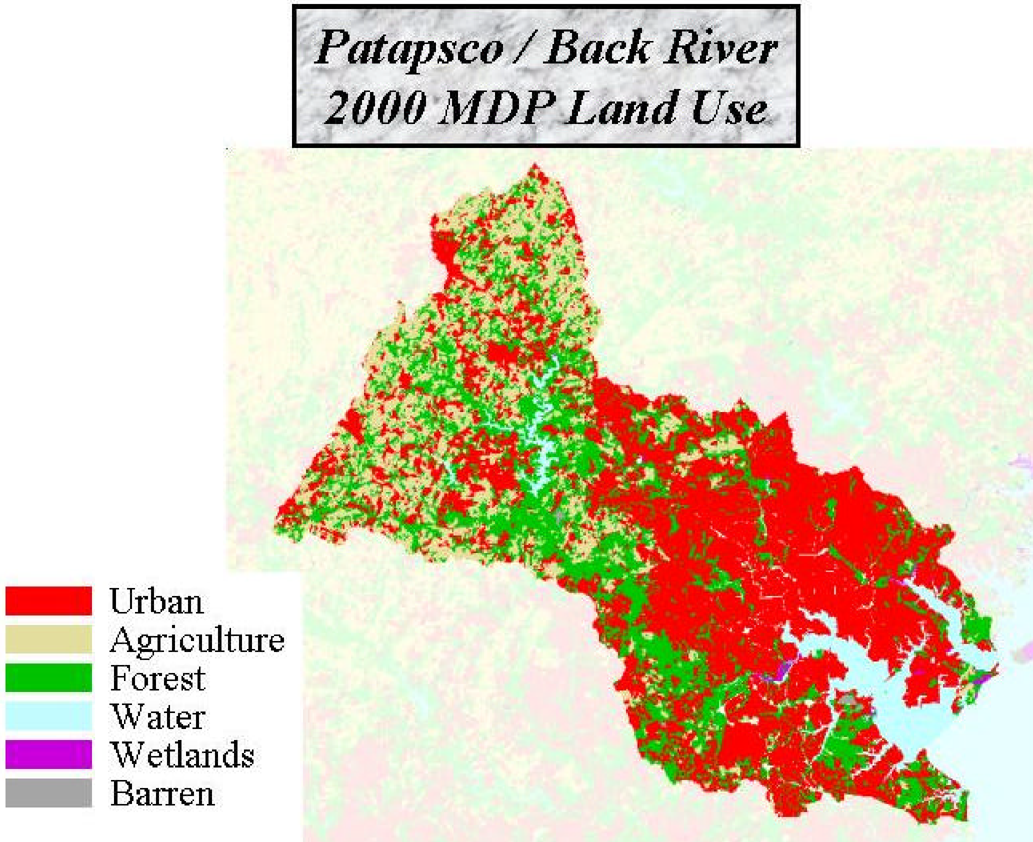


Figure PB2 – Wastewater Treatment Plants in the Patapsco/Back River Basin

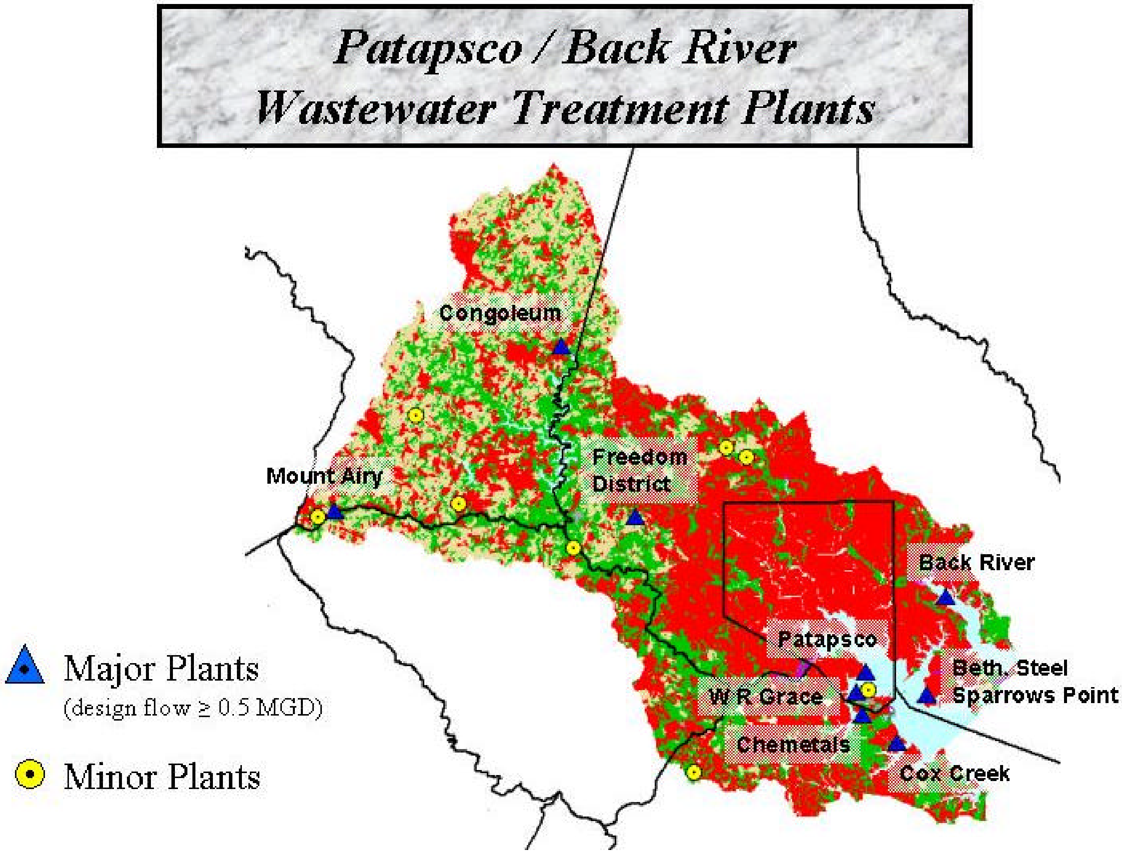


Figure PB3 – 1985 and 2002 Nitrogen Contribution to the Patapsco/Back River by Source.

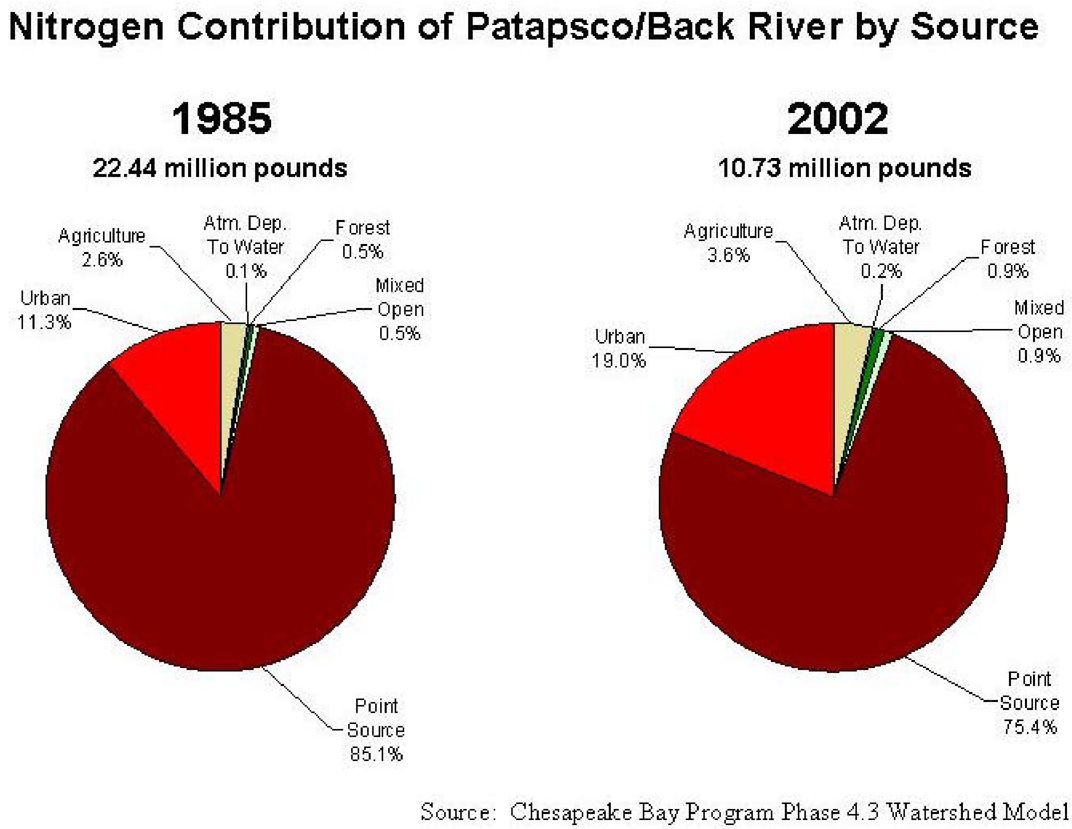


Figure PB4 – 1985 and 2002 Phosphorus contribution to the Patapsco/Back River by Source.

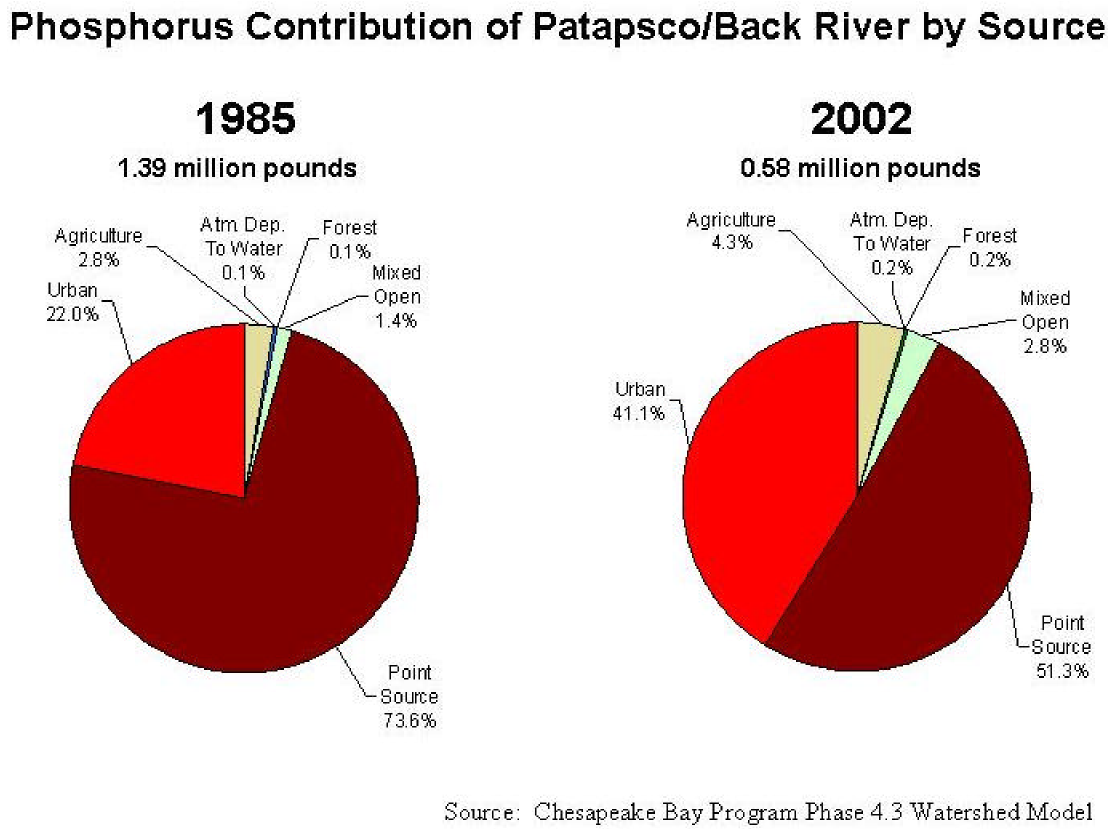
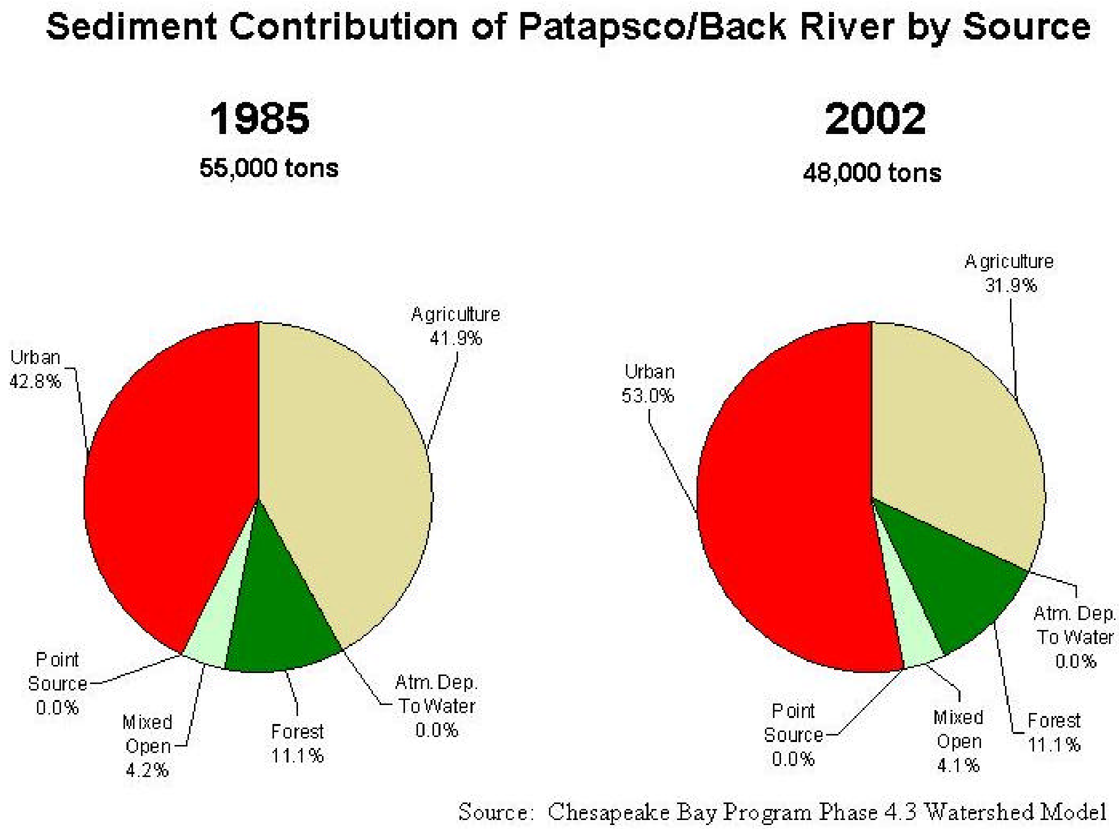


Figure PB5 – 1985 and 2002 Sediment Contribution to the Patapsco/Back River by Source.



Source: Chesapeake Bay Watershed Model

Overview of Monitoring Results

Water and Habitat Quality

Non-tidal Water Quality Monitoring Information Sources

Much useful information on non-tidal water quality is available on the Internet. The State of Maryland's Biological Stream Survey (MBSS) basin fact sheets and basin summaries are available at:
http://www.dnr.state.md.us/streams/mbss/mbss_fs_table.html
MBSS also reports stream quality information summarized by county at:
http://www.dnr.state.md.us/streams/mbss/county_pubs.html In addition to these reports and fact sheets, detailed and more recent information and data are also available on the MBSS website: **http://www.dnr.state.md.us/streams/mbss**

Information on the new Watershed Management Tool and stream water quality for Anne Arundel County are available at:
http://www.aacounty.org/LandUse/OECR/index.cfm

Information on Baltimore County water quality sampling is available at:
http://www.co.ba.md.us/Agencies/environment/

Water quality information collected by Maryland's volunteer Stream Waders is available at: **http://www.dnr.state.md.us/streams/mbss/mbss_volun.html**

Long-term Tidal Water Quality Monitoring

Good water quality is essential to support the animals and plants that live or feed in the Patapsco/Back tributaries. Important water quality parameters are measured at two long-term tidal monitoring stations and five long-term nontidal monitoring stations in the Patapsco/Back basin. Parameters measured include nutrients, water clarity (Secchi depth), dissolved oxygen, total suspended solids, and algal abundance.

Current status is determined based on the most recent three-year period (2000-2002). For dissolved oxygen, the current are compared to ecologically meaningful thresholds to assign a status of good, fair, or poor. Thresholds have not been established for the other parameters, so the current data are compared to a baseline data set, and assigned a status of good, fair, or poor, which is only a *relative* status compared to the baseline data. Trends are determined using a non-parametric test for trend (the Seasonal Kendall test). For a detailed description of the methods used to determine status and trends, see http://www.dnr.state.md.us/bay/tribstrat/status_trends_methods.html**.**

Patapsco River water quality was poor for all six parameters (total nitrogen, total phosphorus, algal abundance, total suspended solids, water clarity, and dissolved oxygen). Water quality status was poor in the mesohaline portions of Back River, while status was usually fair or good in the upper portions of the watershed (Figures PB6-

PB11). This was the case for total nitrogen and total phosphorus concentrations. However, improving trends nutrient concentrations were detected throughout most of the watershed. Total suspended solids concentrations were poor at the Patapsco River station, but were relatively good or fair throughout the rest of the watershed.

At the mesohaline stations in Back River, status was poor for abundance of algae and Secchi depth. No strong trends were detected for either parameter. Summer dissolved oxygen status was poor at the Patapsco River station (depth of 14 meters) but good at the shallower Back River station (2 meters deep). A degrading trend in dissolved oxygen values was also detected in the Patapsco.

SAV

The well defined linkage between water quality and submerged aquatic vegetation (SAV) distribution and abundance make SAV communities good barometers of the health of estuarine ecosystems. SAV is important not only as an indicator of water quality, but it is also a critical nursery habitat for many estuarine species. Blue crab post-larvae are 30 times more abundant in SAV beds than adjacent unvegetated areas. Similarly, several species of waterfowl are dependant on SAV as food when they over-winter in the Chesapeake region.

The Chesapeake Bay Program has developed new criteria for determining SAV habitat suitability of an area based on water quality. The APercent Light at Leaf@ habitat requirement assesses the amount of available light reaching the leaf surface of SAV after being attenuated in the water column and by epiphytic growth on the leaves themselves. The document describing this new model is found on the Chesapeake Bay Program website (www.chesapeakebay.net/pubs/sav/index.html). The older AHabitat Requirements@ of five water quality parameters are still used for diagnostic purposes . Re-establishment of SAV is measured against the ATier 1 Goal@, an effort to restore SAV to any areas known to contain SAV from 1971 to 1990.

In the Back River basin, the Virginia Institute of Marine Science (VIMS) has never recorded SAV in this area over the time frame 1984 to 2001 (www.vims.edu/bio/sav/), and there is no Tier I goal for this system (Figure PB12). Also, there is no ground-truthing information available for this area. The water quality data from the monitoring station located between Stansbury Point and Muddy Gut indicates that Back River fails all applicable habitat requirements for SAV growth and survival (percent light at leaf, light attenuation, phosphorus and algae concentrations, there is no nitrogen habitat requirement for oligohaline areas like Back River). Surprisingly, wild celery (*Vallisneria americana*) transplants performed in 1999, 2000, 2001 and 2002 in Long Creek (near the launch ramp at Rocky Point Park, Back River Neck area, near the mouth of Back River) have performed very well (www.dnr.state.md.us/bay/sav/rocky_point.html). In spring of 2001, there were approximately 60 square meters of plants that survived the winter from the 1999, 2000 plantings, and the year 2001 transplants had expanded beyond the original planting area (>100% survival). There was evidence of the plants successfully flowering and producing seeds, in addition to tubers (overwinter structures), which will hopefully lead to increased natural recovery in the future. This site will have additional wild celery transplants in 2002.

For the mesohaline Patapsco River, only very small amounts of SAV have been recorded by VIMS (www.vims.edu/bio/sav/), with the highest coverage in 1998 (14.5 acres) (Figure PB12). These beds are exclusively identified in Shallow Creek, near the northern mouth of the Patapsco River. The Tier I goal is 124 acres, and this number represents SAV that was present in 1978 and 1979, as there was no SAV present in the 1984 to 1990 time frame. Ground-truthing has found 7 species of SAV in the Patapsco, frequently in beds too small to be mapped by the aerial survey, located in Shallow, Marley, Stony and Rock Creek. In order of occurrence, these species are: Eurasian watermilfoil, horned pondweed, elodea, redhead grass, wild celery, curly pondweed and coontail. Water quality data from the monitoring station located near the Key Bridge and Fort Carroll island indicates suspended solid levels meet the habitat requirements for SAV and phosphorous concentrations are borderline, while light attenuation, nitrogen and algae level fail.

Figure PB6 – Total Nitrogen Concentrations in the Patapsco/Back River Basin

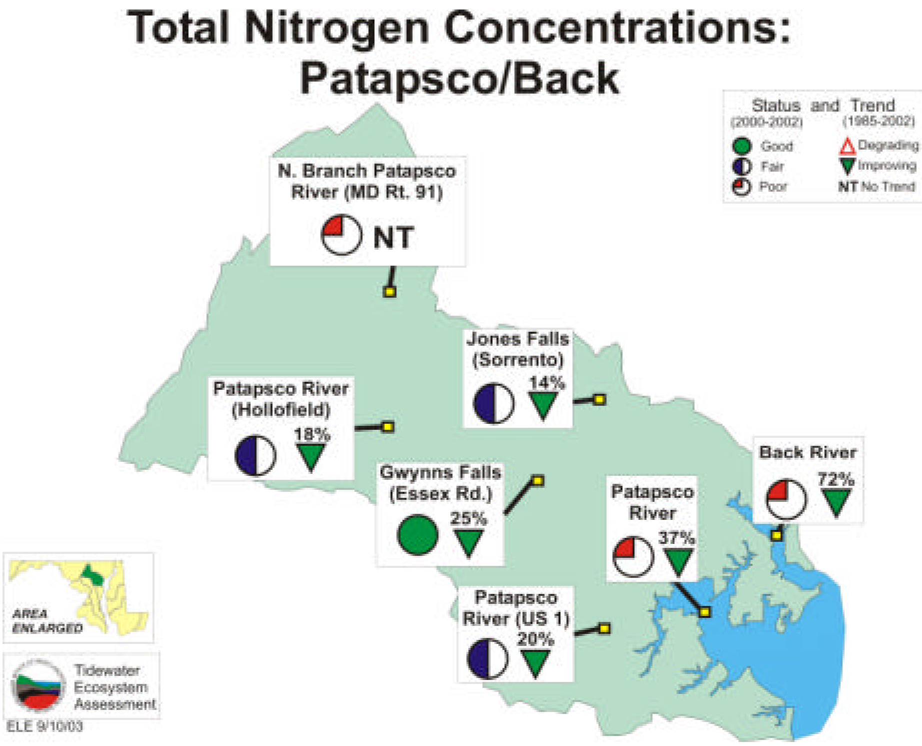


Figure PB7 – Total Phosphorus Concentrations in the Patapsco/Back River Basin

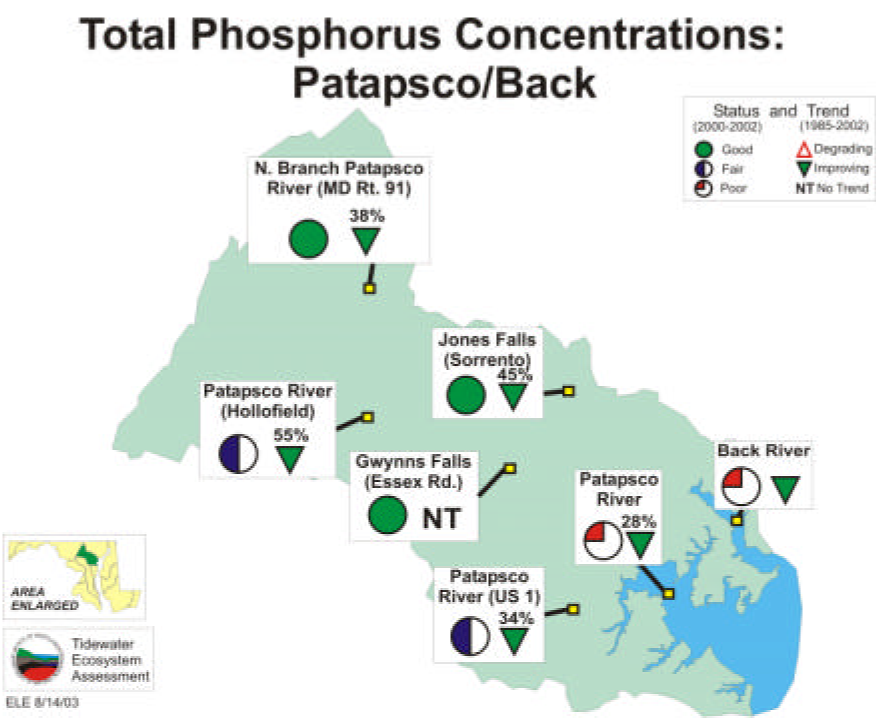


Figure PB8 – Abundance of Algae in the Patapsco/Back River Basin

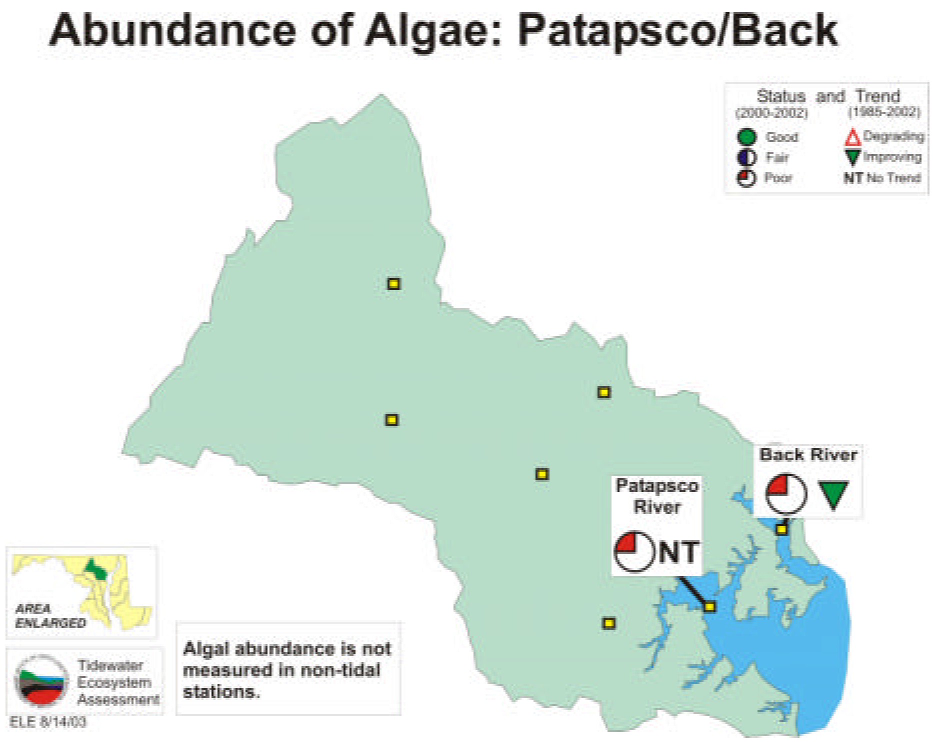


Figure PB9 – Total Suspended Solids in the Patapsco/Back River Basin

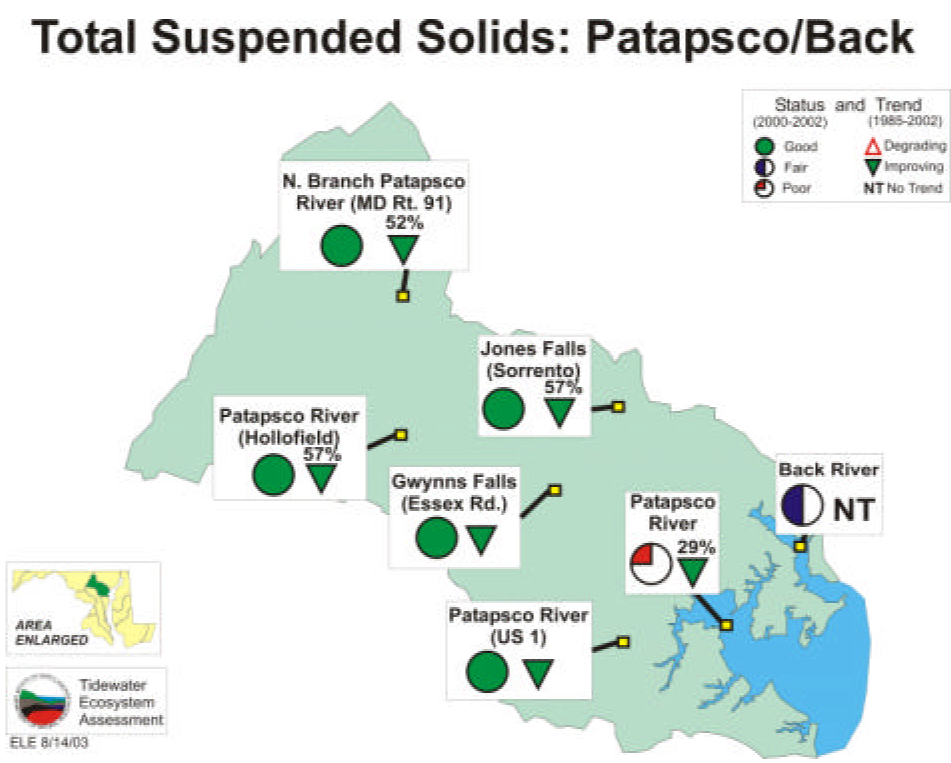


Figure PB10 – Secchi Depth in the Patapsco/Back River Basin

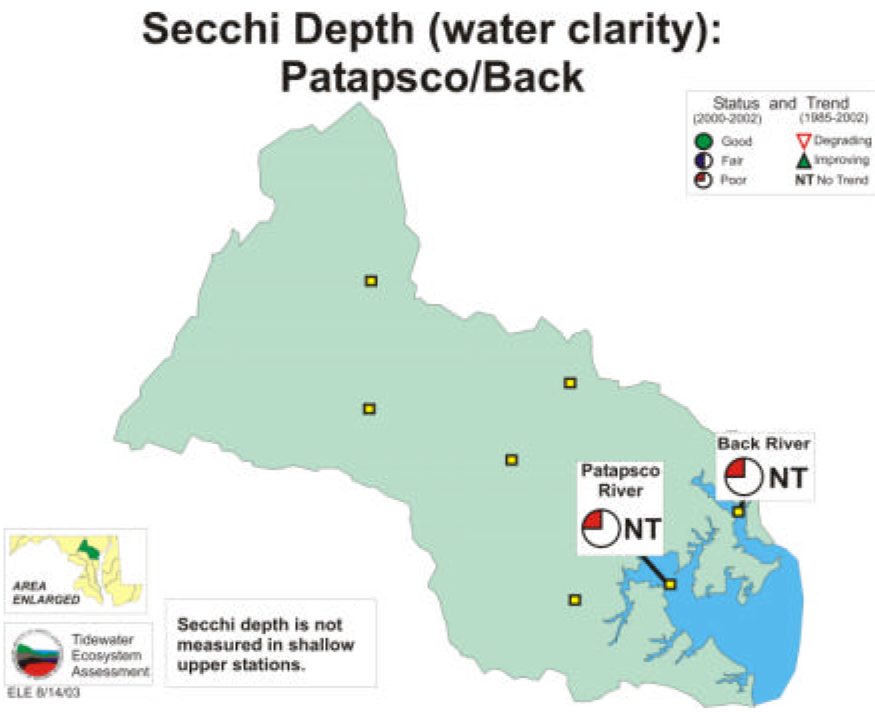


Figure PB11 – Summer Dissolved Oxygen in the Patapsco/Back River Basin

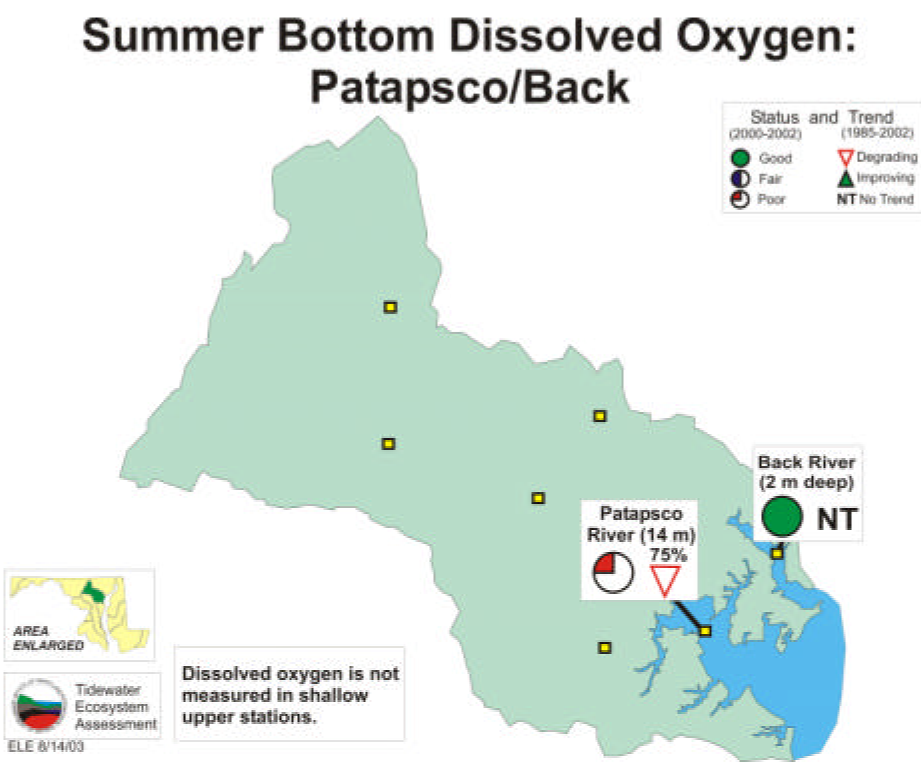
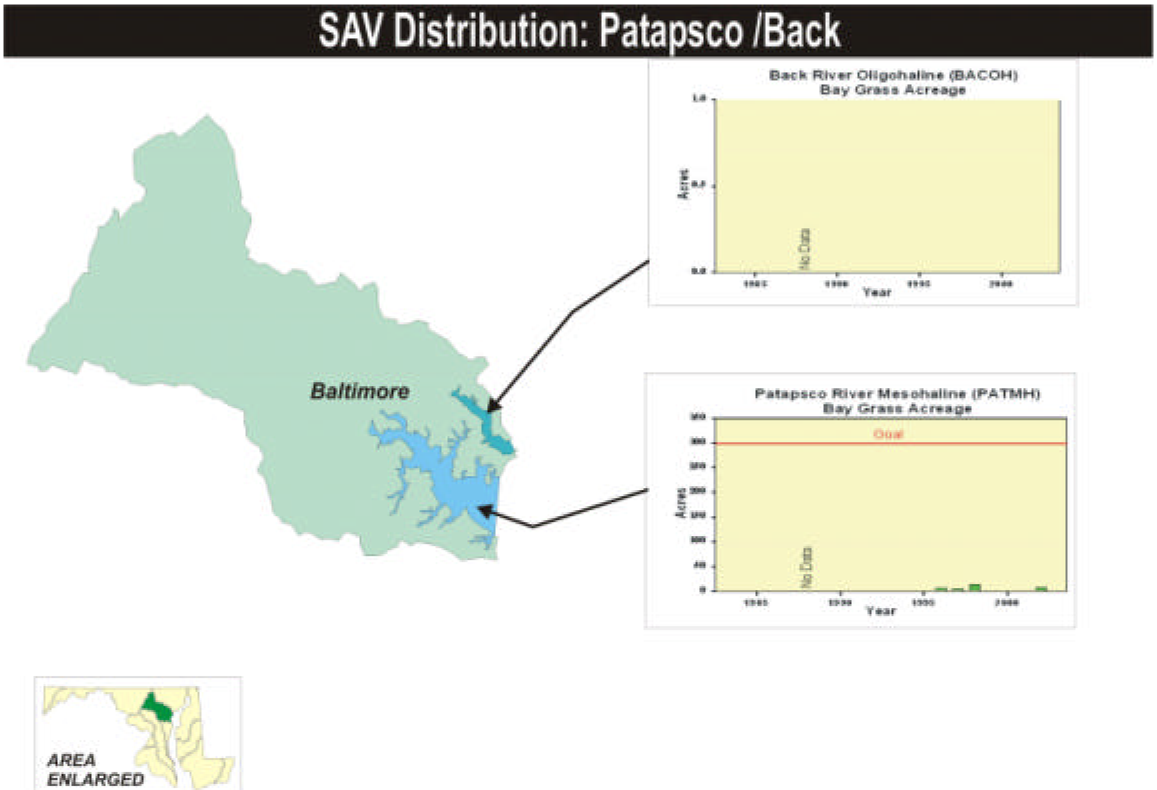


Figure PB12 –Bay Grasses (Submerged Aquatic Vegetation) Distribution in the Patapsco/Back Basin



Benthic Community

The benthic community forms an integral part of the ecosystem in estuarine systems. For example, small worms and crustaceans are key food items for crabs and demersal fish, such as spot and croaker. Suspension feeders that live in the sediments, such as clams, can be extremely important in removing excess algae from the water column. Benthic macroinvertebrates are reliable and sensitive indicators of estuarine habitat quality.

Benthic monitoring includes both probability-based sampling (sampling sites are selected at random) and fixed station sampling (the same site is sampled every year). A benthic index of biotic integrity (B-IBI) is determined for each site (based on abundance, species diversity, etc.). The B-IBI serves as a single-number indicator of benthic community health. For a more details on the methods used in the benthic monitoring program see http://esm.versar.com/Vcb/Benthos/backgrou.htm

For the period from 1985-2000, benthic community condition was largely degraded in the Patapsco and Back River basins. No trends in the B-IBI were detected at any of the long-term monitoring stations (Table PB2). Benthic community status was severely degraded for Patapsco River stations and moderately degraded for the Back River station, with conditions that have not improved significantly since monitoring at these stations began.

Figure PB13. Trends in benthic community condition at Patapsco and Back River long-term monitoring stations, 1985-2000. Trends were identified using the van Belle and Hughes (1984) procedure. Current mean B-IBI and condition are based on 1998-2000 values. Initial mean B-IBI and condition are based on 1985-1987 values for Sta. 22 and 23, 1989-1991 values for Sta. 201 and 202, and 1995-1997 values for Sta. 203. NS: not significant.

Station[1]	Trend Significance	Median Slope (B-IBI units/yr)	Current Condition (1998-2000)	Initial Condition (See heading)
22 Middle Branch	NS	0.00	1.76 (Severely Degraded)	2.08 (Degraded)
23 Patapsco River	NS	0.00	1.84 (Severely Degraded)	2.49 (Degraded)
201 Bear Creek	NS	0.00	1.22 (Severely Degraded)	1.10 (Severely Degraded)
202 Curtis Bay	NS	0.00	1.31 (Severely Degraded)	1.40 (Severely Degraded)
203 Back River	NS	0.02	2.18 (Degraded)	1.93 (Severely Degraded)

[1]Sta. 22 Middle Branch, low mesohaline habitat, 39.254940 lat., 76.587354 long.
Sta. 23 Patapsco River, low mesohaline habitat, 39.208275 lat., 76.523352 long.
Sta. 201 Bear Creek, low mesohaline habitat, 39.234275 lat., 76.497184 long.
Sta. 202 Curtis Branch, low mesohaline habitat, 39.217940 lat., 76.563853 long.
Sta. 203 Back River, oligohaline habitat, 39.275107 lat., 76.446015 long.

Nutrient Limitation

Like all plants, phytoplankton need nitrogen, phosphorus, light, and suitable water temperatures to grow. If light is adequate and the water temperature is appropriate, phytoplankton will continue to grow as long as unlimited amounts of nutrients are available. If nutrients are not unlimited, then the ratio of nitrogen to phosphorus affects phytoplankton growth. (Phytoplankton generally use nitrogen and phosphorus at a ratio of 16:1, that is, 16 times as much nitrogen is needed as phosphorus.) If one of the nutrients is not available in the adequate quantity, phytoplankton growth is 'limited' by that nutrient. If both nutrients are available in enough excess (regardless of the relative proportion of them) that the phytoplankton can not use them all even when they are growing as fast as they can under the existing temperature and light conditions, then the system is 'nutrient saturated.'

Nitrogen limitation occurs when there is insufficient nitrogen, i.e., there is excess phosphorus. Nitrogen limitation often happens in the summer and fall after stormwater flows are lower (so less nitrogen is being added to the water) and some of the nitrogen has already been used up by phytoplankton growth during the spring. If an area is nitrogen limited, then adding nitrogen will increase phytoplankton growth.

Phosphorus limitation occurs when there is insufficient phosphorus, i.e. there is excess nitrogen. If an area is phosphorus limited, then adding phosphorus will increase phytoplankton growth. Phosphorus limitation occurs in some locations in the spring when large amounts of nitrogen are added to the estuary from stormwater flow.

If an area is light or temperature limited, then both nitrogen and phosphorus are available in excess and a situation of nutrient saturation occurs. In this case, if phytoplankton are exposed to appropriate water temperatures and sufficient light, they will grow. If an area is both nitrogen and phosphorus limited, then both nitrogen and phosphorus must be added to increase algal growth.

Managers can use the nutrient limitation model to predict which nutrient is limiting at a given location and use the information to assess what management approach might be the most effective for controlling excess phytoplankton growth. If an area is phosphorus limited, then reducing phosphorus will bring the most immediate reductions in phytoplankton grown. However, if nitrogen levels are not also reduced, the excess nitrogen that goes unused can be exported downstream. This excess nitrogen may reach an area that is nitrogen limited, fueling phytoplankton growth in that downstream area.

The nutrient limitation predictions are a valuable tool, but they must be used in conjunction with other water quality and watershed information to fully assess and evaluate the best management approach.

The nutrient limitation models were used to predict nutrient limitation for the stations in the Patapsco and the Back Rivers. Results are summarized for the most recent three-year period (2000-2002) by season: winter (December-February), spring (March-May), summer (July-September) and fall (October-November). Managers can use these predictions to assess what management approach will be the most effective for controlling excess phytoplankton growth. Interpreting the results can be a little counter-intuitive, however. Remember that nitrogen limited means that *phosphorus* is in excess. Initially, it would seem that the best management strategy would be to reduce phosphorus inputs. However, it may actually be more cost effective to further reduce *nitrogen* inputs to increase the amount of 'unbalance' in the relative proportions of nutrients so that phytoplankton growth is even more limited. When used along with other information available from the water quality and watershed management programs, these predictions will allow managers to make more cost-effective management decisions.

Back River

Water and Habitat Quality

Both total nitrogen and total phosphorus had poor status, but improved over the 1985-2002 period. Algal abundance and Secchi depth each had poor status, with a slight improvement in algal concentration detected. Total suspended solids concentrations were relatively fair and dissolved oxygen status was good; there were no significant trends in these two parameters.

SAV

No SAV has ever been observed by overflights of the Back River. There is no Tier I acreage goal for this system, and no ground truthing information is available.

Benthos

In the Back River estuary, most sites were degraded during the period 1995-2000. The probability of observing degraded benthos was 62 percent (Figure PB14). Stress from low dissolved oxygen did not appear to be a problem in the Back River. Total abundance met restoration goals except for two sites that exhibited very high densities of organisms. However, the benthos was strongly dominated by opportunistic organisms indicative of pollution.

Figure PB14. Number of sites failing the B-IBI and probabilities (and SE) of observing degraded benthos, non-degraded benthos, or benthos of intermediate condition (indeterminate for low salinity habitats) for Patapsco/Back River Basin segments, 1995-2000. Segment codes: OH = oligohaline, MH = mesohaline.

Segment	River	Number of Sites	Sites with B-IBI<3.0	P Deg.	P Non-deg.	P Interm.
PATMH	Patapsco	56	37	61.7 (6.3)	21.7 (5.3)	20.0 (5.2)
BACOH	Back	9	7	61.5 (13.5)	23.1 (11.7)	30.8 (12.8)

Nutrient Limitation

Back River (WT4.1) - On an annual basis, phytoplankton growth is nutrient saturated (light or temperature limited or no limitation) 75 percent of the year. Winter growth is entirely nutrient saturated. In spring, growth is nitrogen limited about 10 percent of the time and is otherwise nutrient saturated. In summer, growth is nitrogen limited about 30 percent of the time and phosphorus limited less than 10 percent of the time. In fall, growth is phosphorus limited half the time and otherwise is nutrient saturated. Total nitrogen, dissolved inorganic nitrogen, and total phosphorus concentrations are all relatively poor at this station, but nitrogen concentration is improving (decreasing). Dissolved inorganic phosphorus concentration is relatively fair. The ratio of total nitrogen to total phosphorus and the ratio of dissolved inorganic nitrogen to dissolved inorganic phosphorus ratios are both decreasing. The dissolved inorganic nitrogen to dissolved inorganic phosphorus ratio is relatively high in the fall which suggests that reductions in phosphorus may be the most effective means of controlling phytoplankton growth in that season. Reductions in nitrogen will further increase occurrences of nitrogen limitation in the summer. Reductions in both nutrients will be needed to limit growth in the winter and spring. See Appendix B for details.

Patapsco River

Water and Habitat Quality

Total nitrogen and total phosphorus concentrations had poor status, but improving trends were detected for both parameters from 1985 to 2002. Algal abundance and Secchi depth each had poor status and no significant trends. Total suspended solids concentrations had poor status with no an increasing (worsening) trend. Summer dissolved oxygen status was poor in the tidal station of the Patapsco River, and a degrading trend in dissolved oxygen was detected.

SAV

Only very small amounts of SAV have been observed by overflights of the Patapsco River. SAV acreages in this system are well below the Tier I goal of 124 acres. Ground-truthing has identified seven species of SAV in the Patapsco, often in beds too small to be mapped by the aerial survey. Species identified by ground-truthing include Eurasian watermilfoil, horned pondweed, elodea, redhead grass, wild celery, curly pondweed and coontail.

Benthos

Benthic community condition in the Patapsco River estuary for the period 1995-2000 was mostly degraded. The probability of observing degraded benthos was 62 percent (Table PB1). Condition was worst in the upper part of the estuary, above the Francis Scott Key Bridge. The B-IBI classified benthic community condition as severely degraded in this part of the estuary, as well as in Curtis Creek, Stony Creek, and along the deep channel southeast of Sparrows Point. Most sites failing to meet the restoration goals failed because of low abundance and/or low biomass and diversity. Thirty percent of the degraded sites were associated with low dissolved oxygen conditions, and 22 percent were azoic. However, 19 percent of the degraded sites exhibited excess abundance of organisms, a condition that is often associated with organic enrichment. Excess abundance was most prevalent in the shallow flats near Stony Point. This condition may be linked to the large phytoplankton blooms that are known to occur in the Patapsco River estuary. Phytoplankton and the decaying organic matter after the blooms provide food for benthic organisms. Large phytoplankton blooms in the Patapsco River estuary occur because of high nutrient concentrations, lack of turbulence, and reduced grazing from copepods.
In addition to organic enrichment and stress from low dissolved oxygen, benthic communities in the Patapsco River estuary are affected by toxic contamination. A previous study comparing sediment quality among Sparrows Point, Bear Creek, Curtis Bay, and Middle Branch sampling strata (Ranasinghe et al. 1994), found benthic community impairment inversely correlated with metal contaminant concentrations. Curtis Bay had the greatest percentage of metal contaminants with concentrations above thresholds at which biological effects are expected, and the more severe impairment. In laboratory bioassay tests (Scott et al. 1991), sediments from Bear Creek were significantly toxic to the amphipod *Leptocheirus plumulosus*.

Nutrient Limitation

Patapsco River (WT5.1) – On an annual basis, phytoplankton growth is phosphorus limited 50 percent of the time and nitrogen limited 20 percent of the time. Winter growth is phosphorus limited about 10 percent of the time and is otherwise nutrient saturated (light or temperature limited or no limitation). In the spring, growth is phosphorus limited more than 75 percent of the time. In the summer, phytoplankton growth is nitrogen limited more than 55 percent of the time and phosphorus limited 30 percent of the time. In the fall, growth is phosphorus limited 70 percent of the time and nitrogen limited almost 15 percent of the time. Total nitrogen, dissolved inorganic nitrogen, and total phosphorus concentrations are all relatively poor but are improving (decreasing); dissolved inorganic phosphorus concentration is fair. The ratio of dissolved inorganic nitrogen to dissolved inorganic phosphorus is decreasing; this ratio is relatively high in the winter and spring and is relatively low in the summer and fall. These patterns indicate that reductions in both nitrogen and phosphorus will be useful for limiting phytoplankton growth. See Appendix B for details.

Plankton

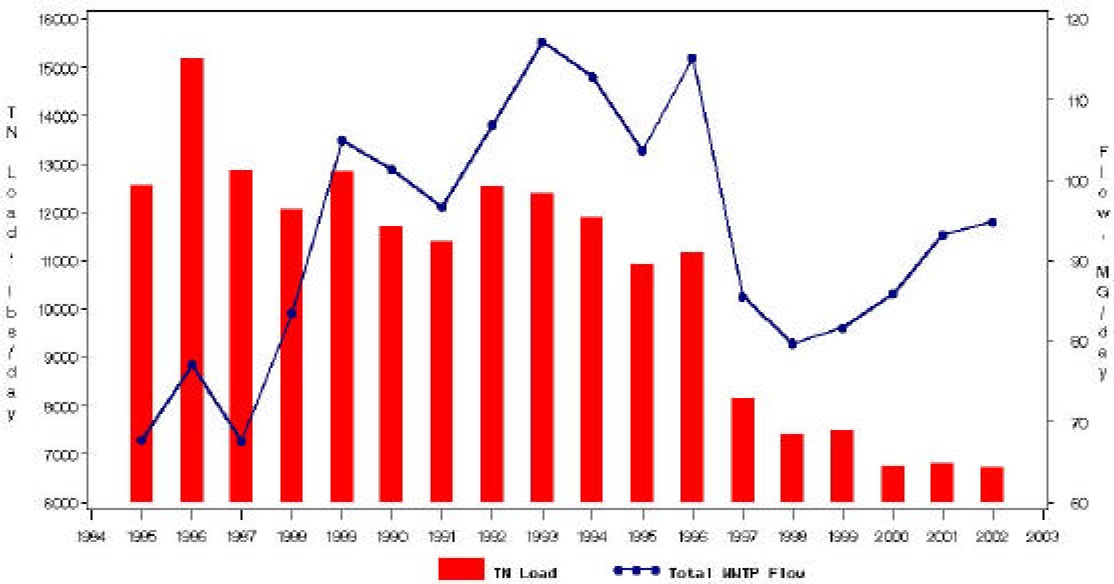
In the phytoplankton data, total phytoplankton biomass degraded both annually and for the summer season from 1985 to 2000. Degrading annual and summer trends were also observed for cyanobacteria to total biomass ratios, cyanophyte biomass, and total biomass to total abundance ratios. These degrading trends signal a shift from larger celled, nutritious phytoplankton species to smaller celled non-nutritious cyanobacteria. Diatom biomass improved in the spring and degraded in the summer. An improving trend for 1985 to 2000 was observed in annual dinoflagellate biomass. Dinoflagellates are considered to be a good food source for zooplankton.

There were very few significant trends in the microzooplankton data. Annually, there was an improvement in copepod nauplii biomass. Seasonally, summer ciliate biomass improved as well.

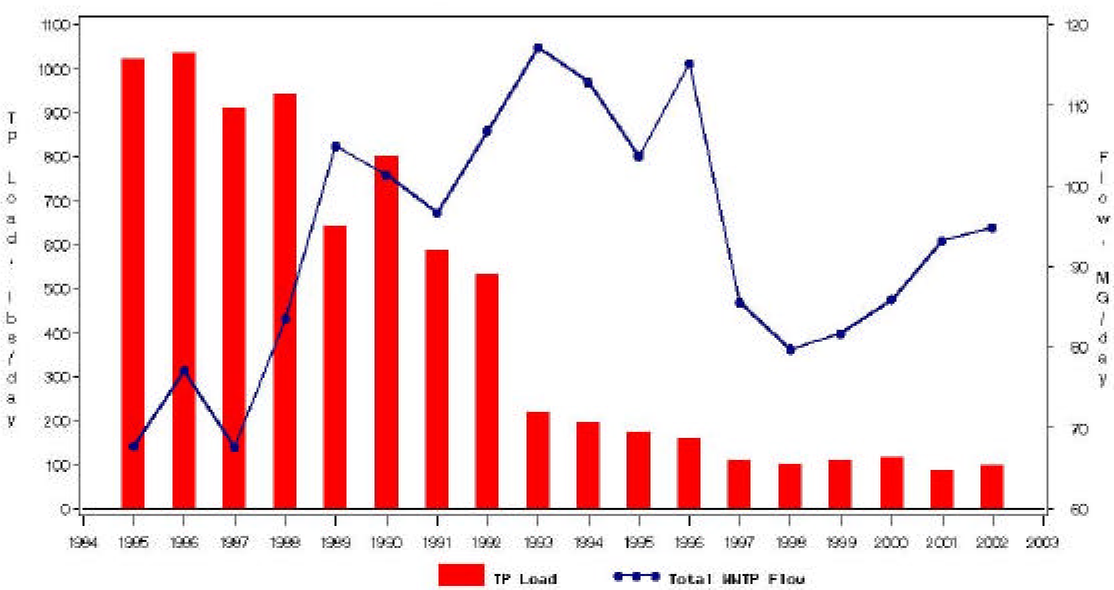
A number of improving trends were recorded in the mesozooplankton data from 1985 to 2000. Improvements were observed in the annual and spring seasons for adult *Acartia tonsa* abundance, mesozooplankton biomass, and total mesozooplankton abundance. Also, an improving trend was detected in spring season adult *Eurytemora affinis* abundance.

Appendix A – Nutrient Loadings from Major Wastewater Treatment Facilities in the Patapsco/Back River Basin

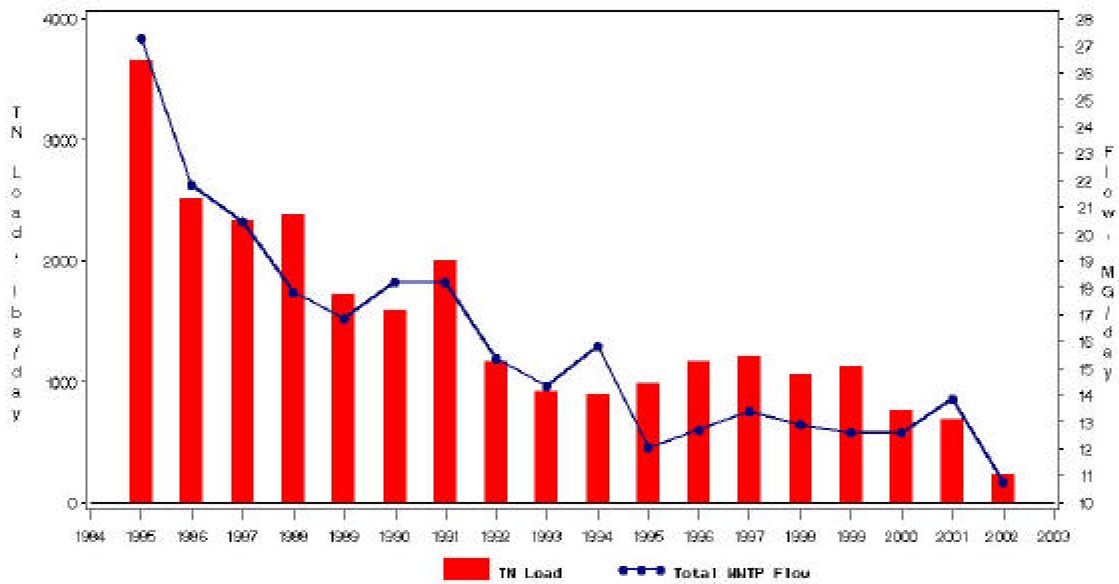
BACK RIVER Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



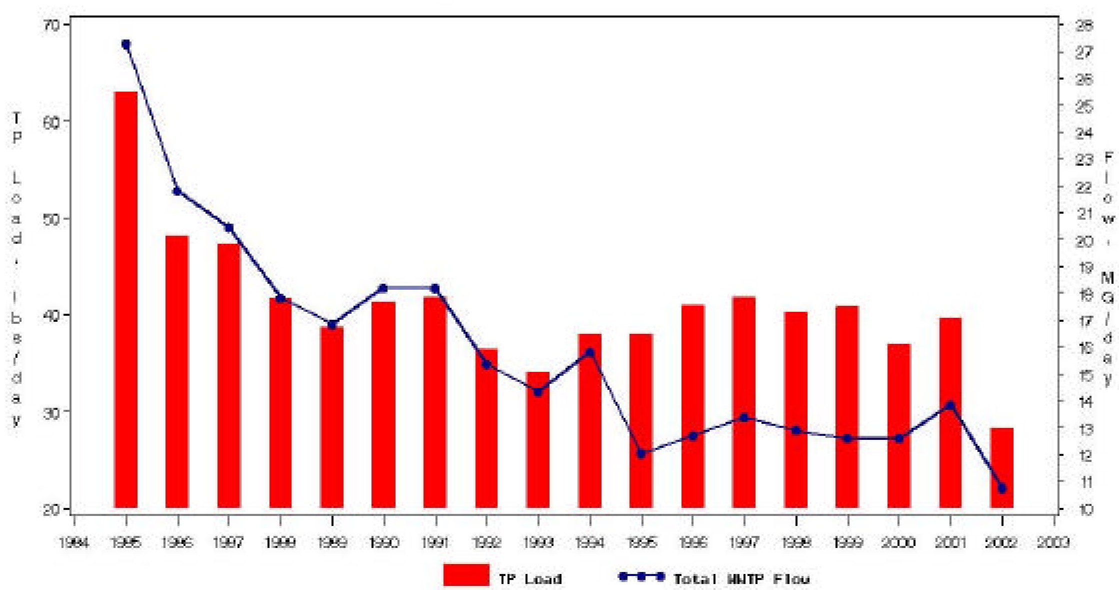
BACK RIVER Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



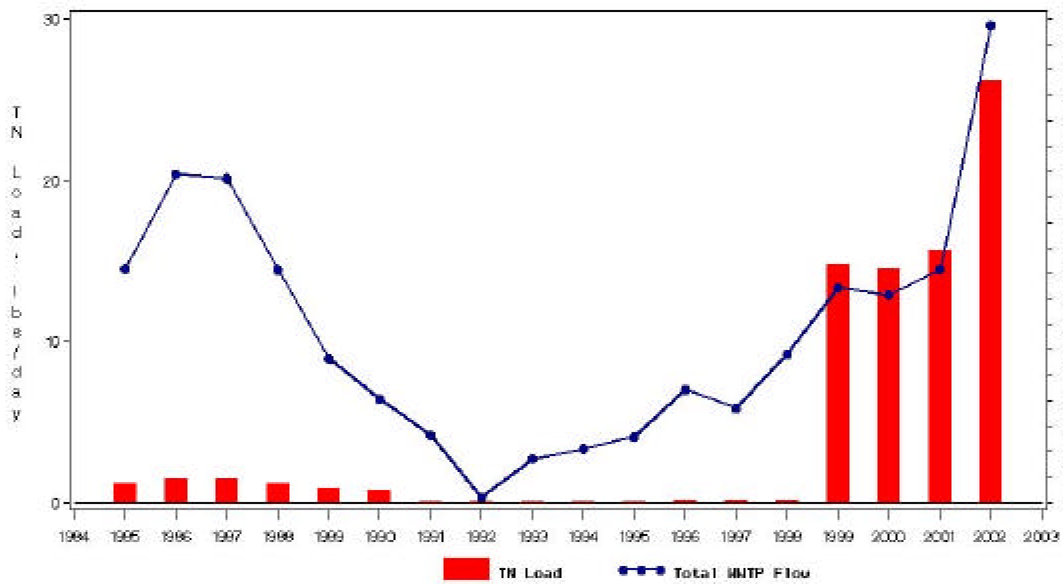
BETHLEHEM STEEL Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



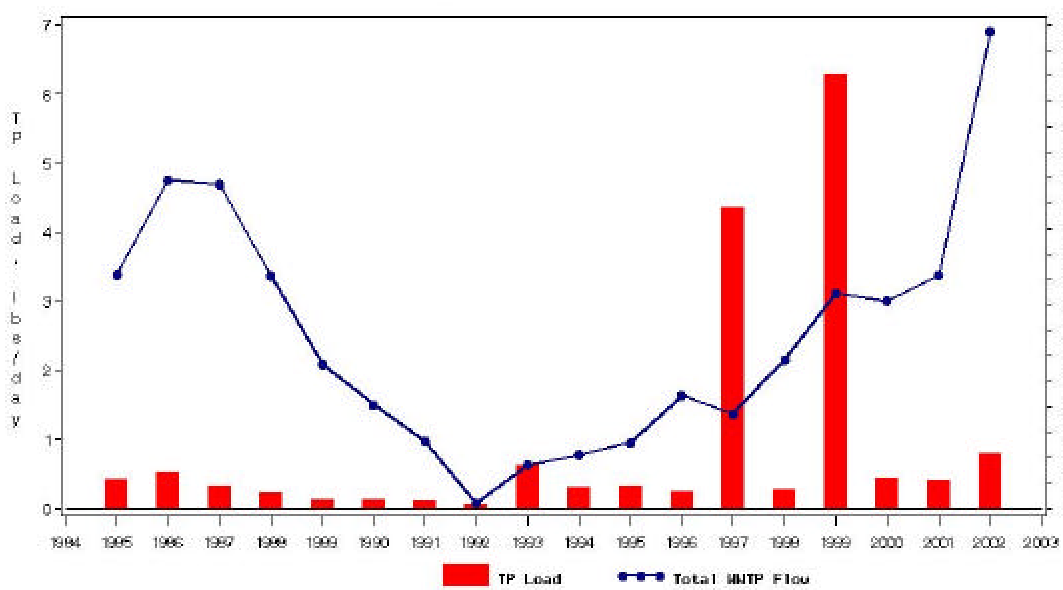
BETHLEHEM STEEL Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



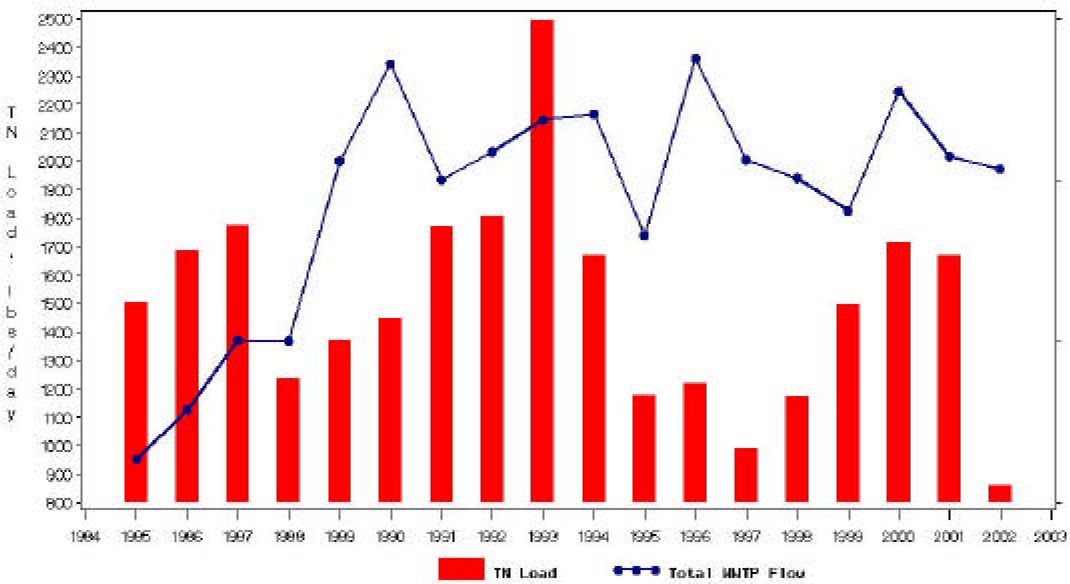
CONGOLEUM Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



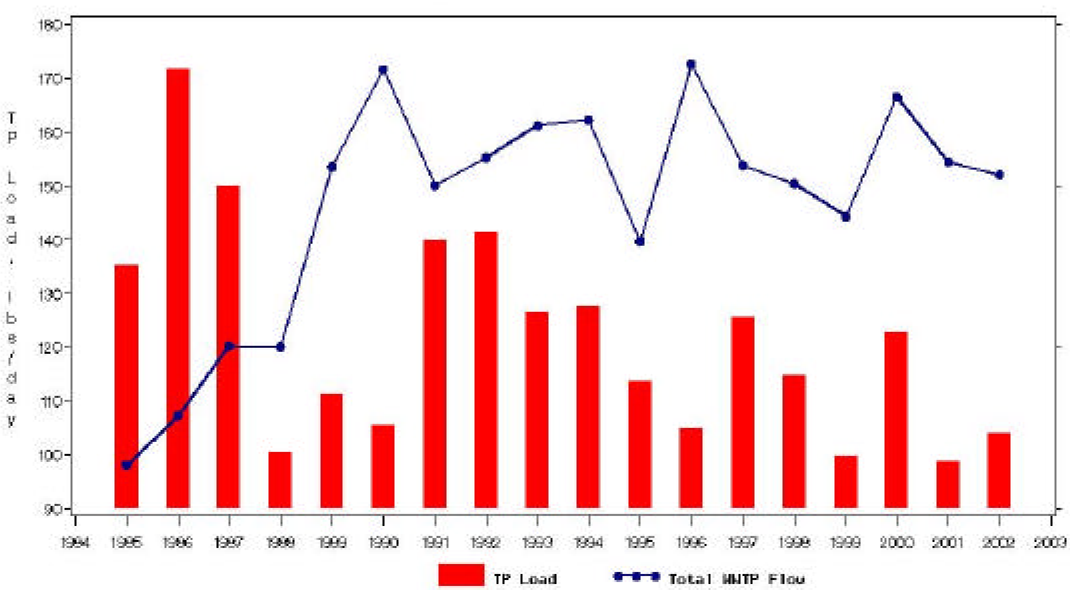
CONGOLEUM Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



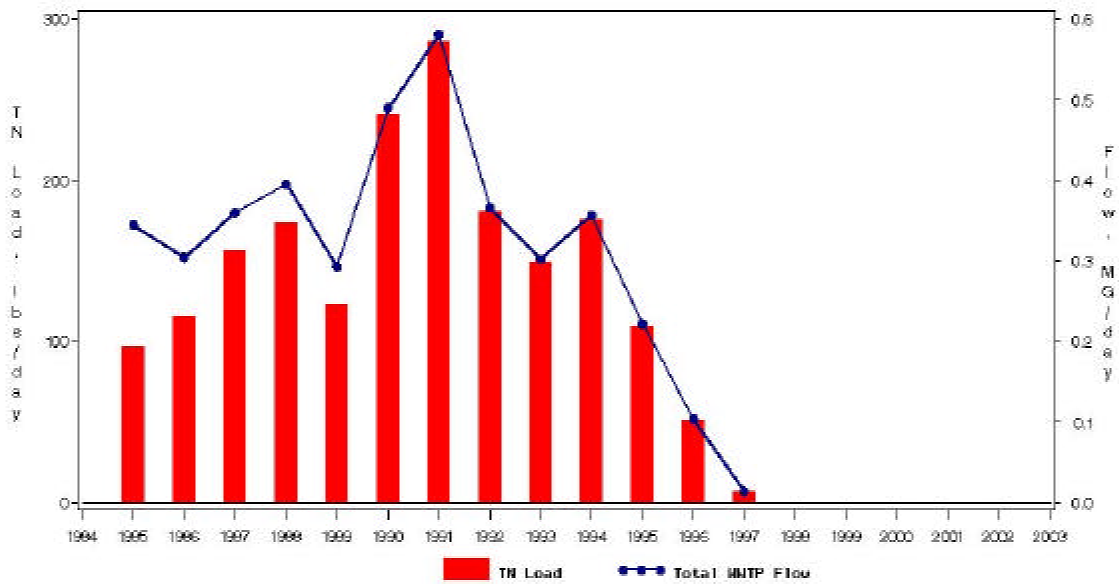
COX CREEK Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



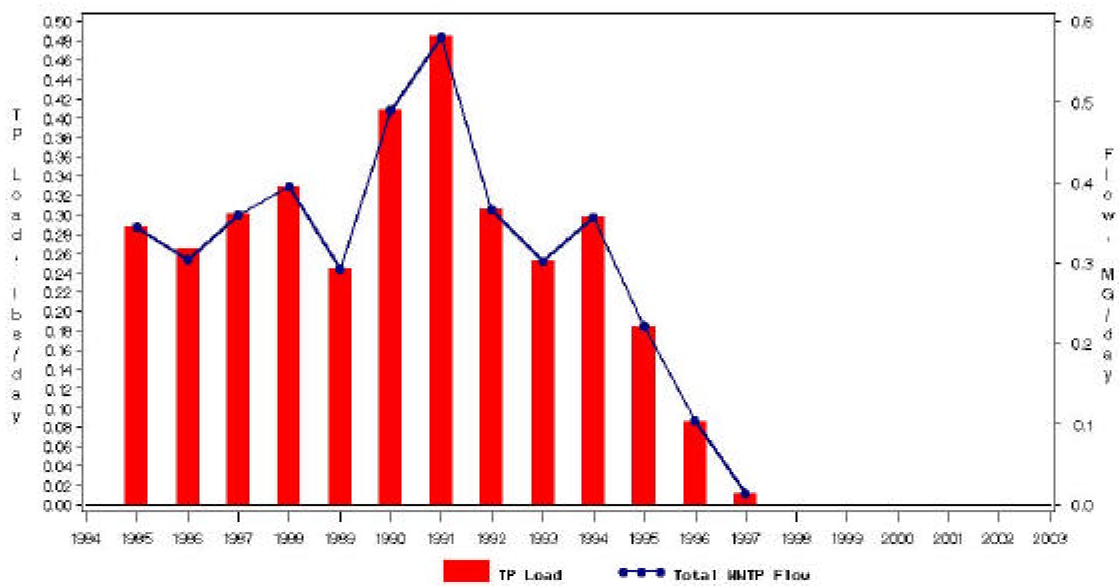
COX CREEK Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



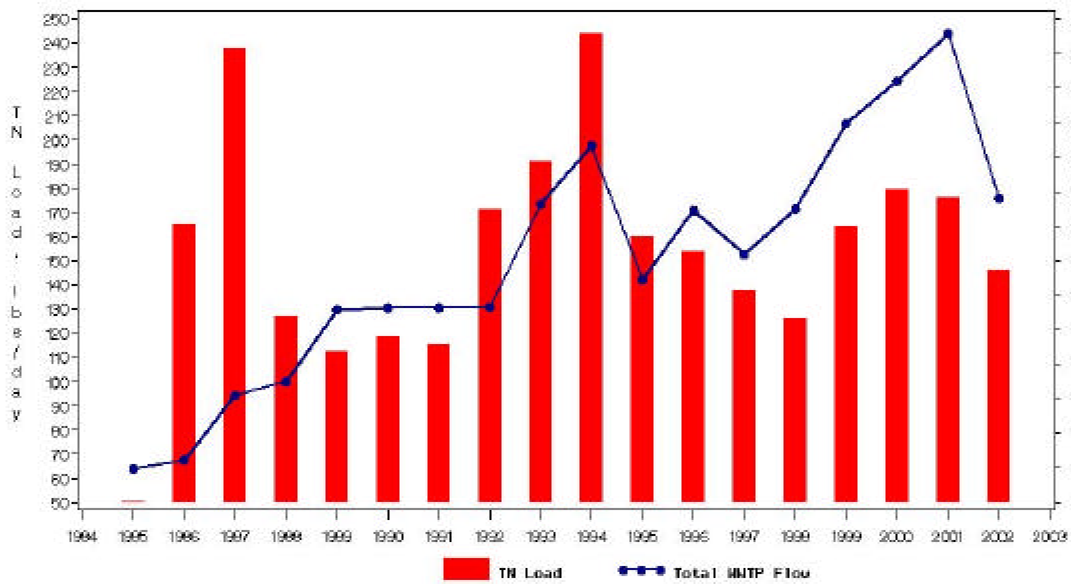
EASTERN STAINLESS Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



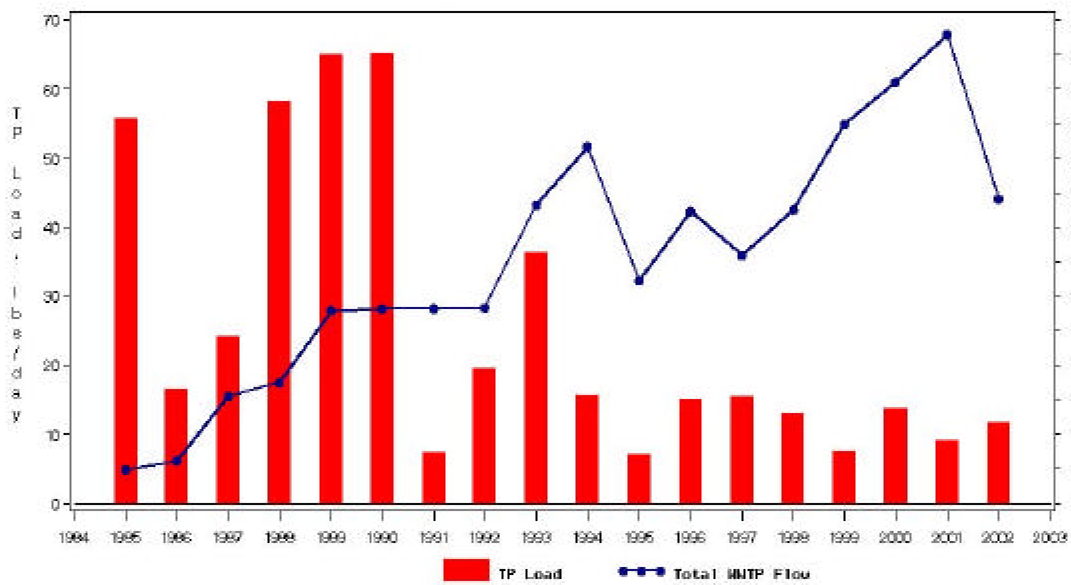
EASTERN STAINLESS Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



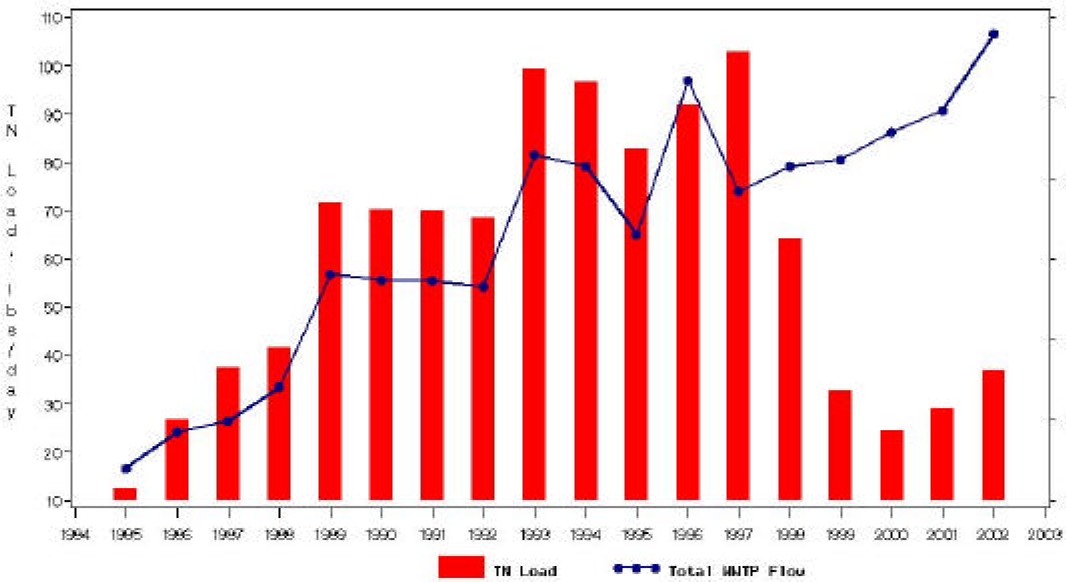
FREEDOM DISTRICT Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



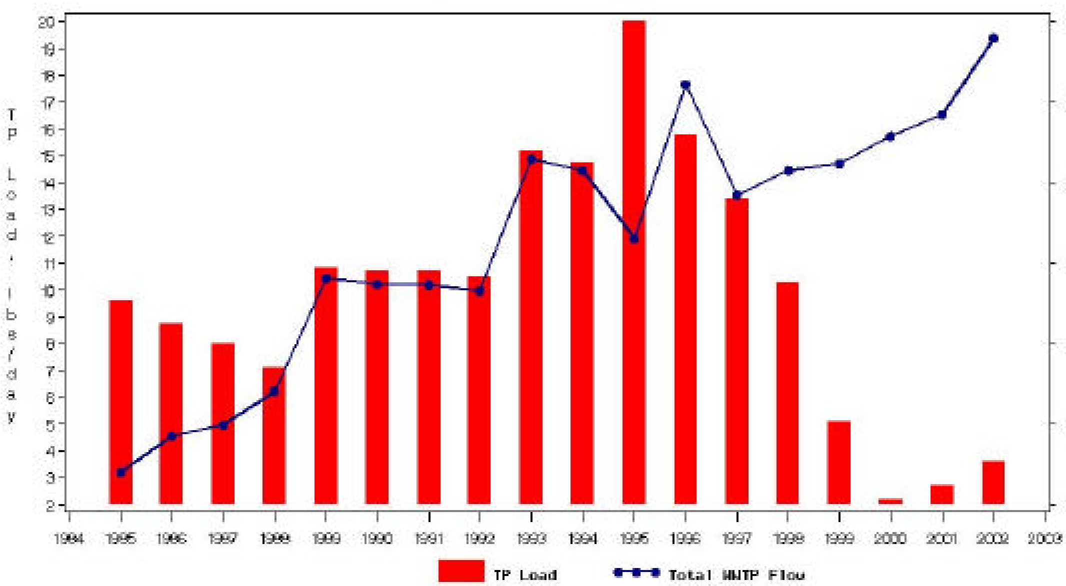
FREEDOM DISTRICT Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



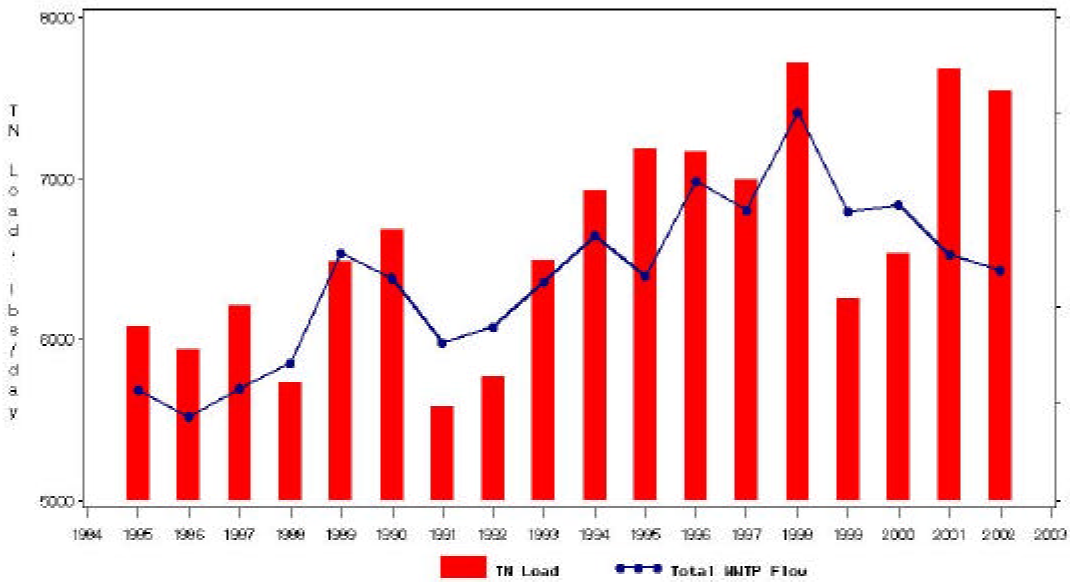
MOUNT AIRY Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



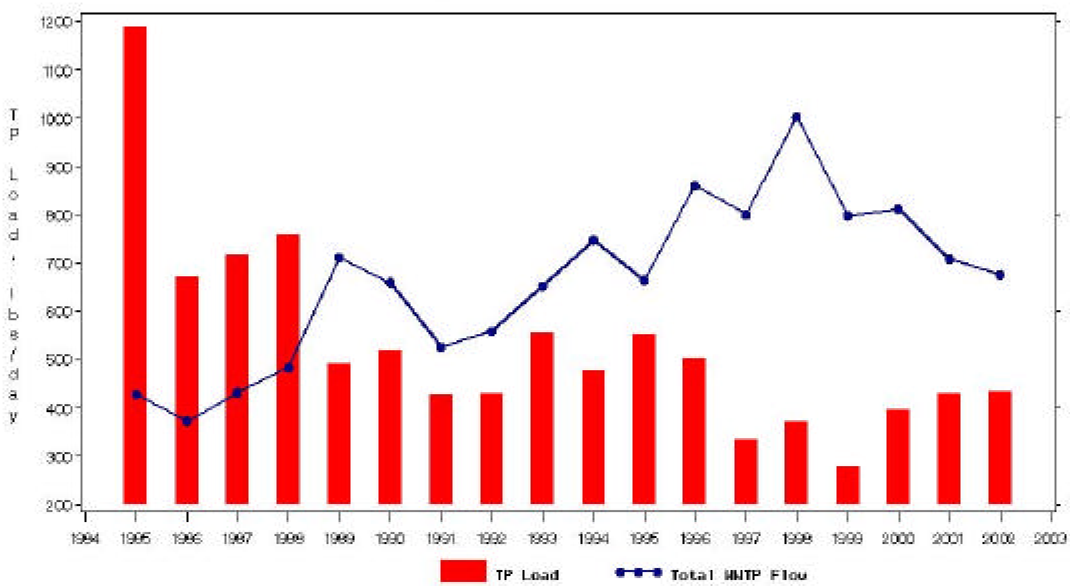
MOUNT AIRY Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



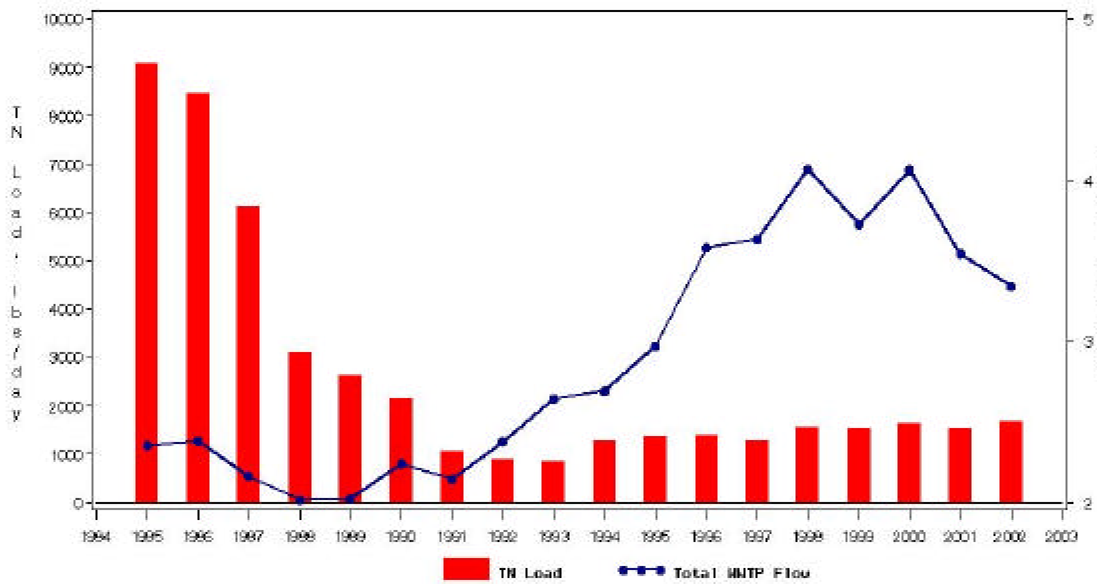
PATAPSCO Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



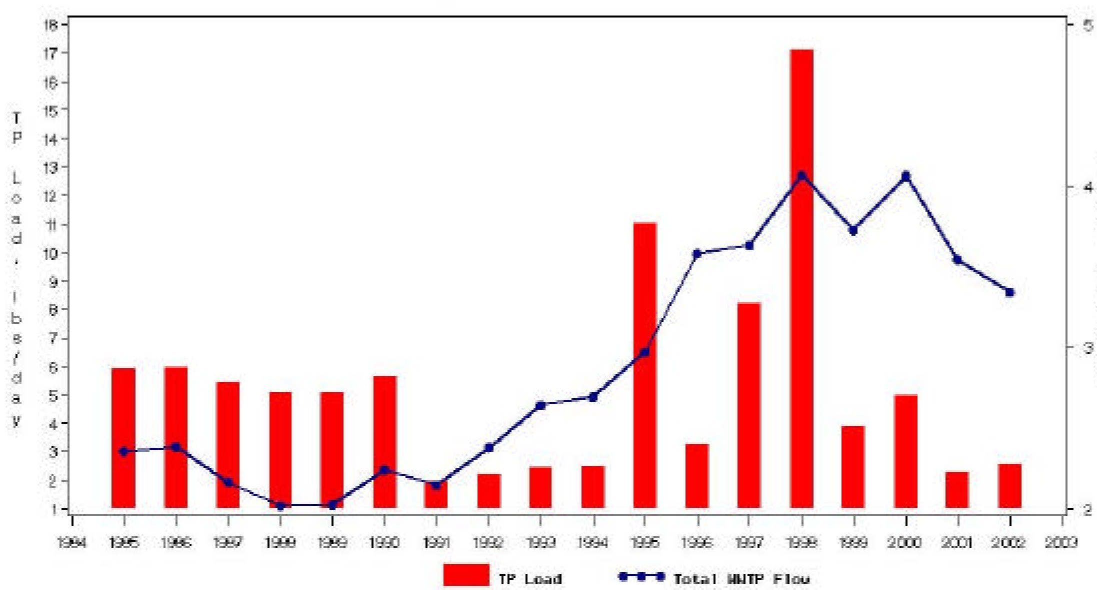
PATAPSCO Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



W R GRACE Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



W R GRACE Wastewater Treatment Plant: Patapsco/Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow

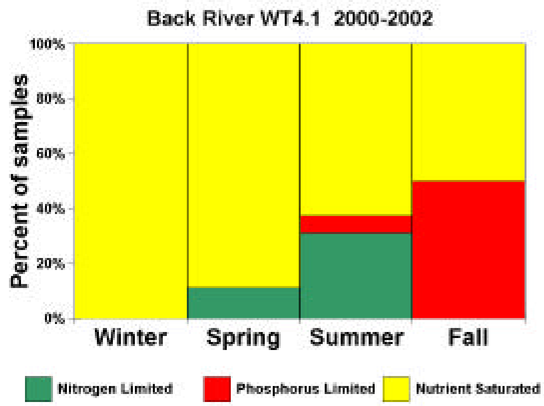


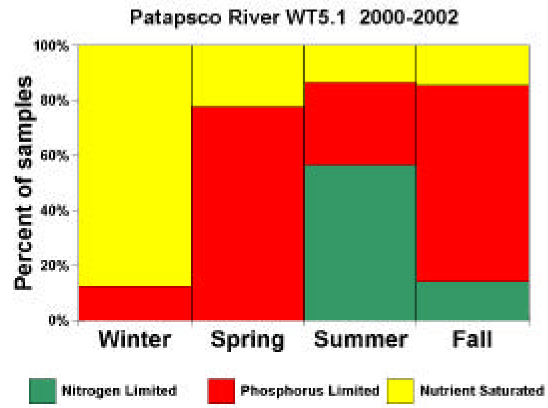
Appendix B – Nutrient Limitation Graphs for the Patapsco/Back Basin

The nutrient limitation models were used to predict nutrient limitation for the stations in the Patapsco and the Back Rivers. Results are summarized for the most recent three-year period (2000-2002) by season: winter (December-February), spring (March-May), summer (July-September) and fall (October-November). Managers can use these predictions to assess what management approach will be the most effective for controlling excess phytoplankton growth. Interpreting the results can be a little counter-intuitive, however. Remember that nitrogen limited means that *phosphorus* is in excess. Initially, it would seem that the best management strategy would be to reduce phosphorus inputs. However, it may actually be more cost effective to further reduce *nitrogen* inputs to increase the amount of 'unbalance' in the relative proportions of nutrients so that phytoplankton growth is even more limited. When used along with other information available from the water quality and watershed management programs, these predictions will allow managers to make more cost-effective management decisions.

Back River (WT4.1) - On an annual basis, phytoplankton growth is nutrient saturated (light or temperature limited or no limitation) 75 percent of the year. Winter growth is entirely nutrient saturated. In spring, growth is nitrogen limited about 10 percent of the time and is otherwise nutrient saturated. In summer, growth is nitrogen limited about 30 percent of the time and phosphorus limited less than 10 percent of the time. In fall, growth is phosphorus limited half the time and otherwise is nutrient saturated. Total nitrogen, dissolved inorganic nitrogen, and total phosphorus concentrations are all relatively poor at this station, but nitrogen concentration is improving (decreasing). Dissolved inorganic phosphorus concentration is relatively fair. The ratio of total nitrogen to total phosphorus and the ratio of dissolved inorganic nitrogen to dissolved inorganic phosphorus ratios are both decreasing. The dissolved inorganic nitrogen to dissolved inorganic phosphorus ratio is relatively high in the fall which suggests that reductions in phosphorus may be the most effective means of controlling phytoplankton growth in that season. Reductions in nitrogen will further increase occurrences of nitrogen limitation in the summer. Reductions in both nutrients will be needed to limit growth in the winter and spring.

Patapsco River (WT5.1) – On an annual basis, phytoplankton growth is phosphorus limited 50 percent of the time and nitrogen limited 20 percent of the time. Winter growth is phosphorus limited about 10 percent of the time and is otherwise nutrient saturated (light or temperature limited or no limitation). In the spring, growth is phosphorus limited more than 75 percent of the time. In the summer, phytoplankton growth is nitrogen limited more than 55 percent of the time and phosphorus limited 30 percent of the time. In the fall, growth is phosphorus limited 70 percent of the time and nitrogen limited almost 15 percent of the time. Total nitrogen, dissolved inorganic nitrogen, and total phosphorus concentrations are all relatively poor but are improving (decreasing); dissolved inorganic phosphorus concentration is fair. The ratio of dissolved inorganic nitrogen to dissolved inorganic phosphorus is decreasing; this ratio is relatively high in the winter and spring and is relatively low in the summer and fall. These patterns indicate that reductions in both nitrogen and phosphorus will be useful for limiting phytoplankton growth.


Back River WT4.1 2000-2002
100%
80%
60%
40%
20%
0%
Percent of samples
Winter
Spring
Summer
Fall
Nitrogen Limited
Phosphorus Limited
Nutrient Saturated


Patapsco River WT5.1 2000-2002
100%
80%
60%
40%
20%
0%
Percent of samples
Winter
Spring
Summer
Fall
Nitrogen Limited
Phosphorus Limited
Nutrient Saturated

Appendix C – References

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